alberta's species at risk program

The 2010 Ferruginous Hawk Inventory and Population Analysis

Alberta Species at Risk Report No. 139

Government of Alberta

The 2010 Ferruginous Hawk Inventory and Population Analysis

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Some of the original work contained in the report was prepared by Brandy L. Downey in 2005.

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EXECUTIVE SUMMARY

The ferruginous hawk (*Buteo regalis*) is a large raptor within the Grassland Natural Region of Alberta; inhabiting areas dominated by native prairie. Schmutz (1982) initiated the Alberta ferruginous hawk inventory to determine the species abundance and distribution in Alberta. The provincial ferruginous hawk population has been estimated every five years since 1982, except between the years 1993 and 1999. The population estimate is based on the number of active nests detected during each inventory year. During the 2010 inventory, 142 quadrats were surveyed; 74 in the high stratum and 68 in the low stratum. Each quadrat measures 6.4 km by 6.4 km. A population estimate of 643 ± 169 breeding pairs of ferruginous hawks was calculated. This population estimate is similar to the 2005 estimate, which implies that the population is relatively stable at low numbers. Trend data collected during the 2000-2010 monitoring period suggests that the population has stabilized since 2000. However, the exact cause for the recent stabilization remains unknown. Overall, Alberta's ferruginous hawk population still remains significantly lower than the 1992, and thus, it is essential to take management actions to assist with the recovery of this species.

1.0 INTRODUCTION

The ferruginous hawk (*Buteo regalis*) is a large (977-2,074 g) diurnal raptor endemic to the Great Plains of western North America, inhabiting shrub-steppe, desert, and grassland habitats (Schmutz 1999, Schmutz et al. 2008). This specialist relies heavily on open, rolling terrain composed mostly of unfragmented native prairie that is readily grazed by cattle (ASRD and ACA 2006), and where nesting structures including lone trees, shelterbelts, cliff ledges, artificial platforms, or level ground, are present (Bechard and Schmutz 1995, Moltzahn pers. obs.). The ferruginous hawk is found in areas where its main prey, the Richardson's ground squirrel (*Spermophilus richardsonii*), are abundant and where human disturbance is minimal (ASRD and ACA 2006).

Beginning in 1982, ferruginous hawk population inventories have been conducted in Alberta every five years, except between the years 1993 and 1999 (Schmutz 1982, 1987, 1993, Stepnisky et al. 2002, Downey 2005). Between 1992 and 2000, the ferruginous hawk population in Alberta plummeted from approximately 1,700 pairs to 700 pairs. As of 2005, the ferruginous hawk breeding population is estimated to be 618 pairs ± 162, which is the lowest population estimate to date (ASRD and ACA 2006). In Alberta, the ferruginous hawk is currently listed as an *Endangered* species under the *Alberta Wildlife Act*, and designated in Canada as a *Threatened* species in schedule 1 of the *Species at Risk Act* (Alberta Ferruginous Hawk Recovery Team 2009, Government of Canada 2010). From a North American perspective, this hawk is currently listed as *Least Concern* by the International Union for Conservation of Nature (BirdLife International 2010).

The objectives of the 2010 ferruginous hawk inventory and population survey are:

1) to determine an estimated number of breeding pairs in Alberta; and
2) to analyze if the Alberta population is exhibiting a positive population trend as outlined in the recovery objectives of the Alberta Ferruginous Hawk Recovery Plan 2009-2014 (Alberta Ferruginous Hawk Recovery Team 2009).

2.0 METHODS

2.1 Project Area

The project area extends north from the Canada/US border to the town of Consort and west from the Saskatchewan border to Calgary and Pincher Creek (Figure 1). The area is approximately 77,947 km^2; and it contains the Mixed-grass, Dry Mixed-grass, and portions of the Northern Fescue and Foothills Fescue Natural Subregions (Achuff 1994). The majority of ferruginous hawks breed within these subregions of the Grassland Natural Region; however, there are a small number of pairs, which are insignificant, that breed outside of the project area (Schmutz 1987, Taylor and Iwassa 2000, Stepnisky et al. 2002). Agriculture is a major land use in this region consisting of pasturelands and cultivated fields. In addition, oil and gas development, towns, and cities are also present. Within the project area, there are a few large, unfragmented areas of native prairie left relatively untouched by the previously mentioned land uses.

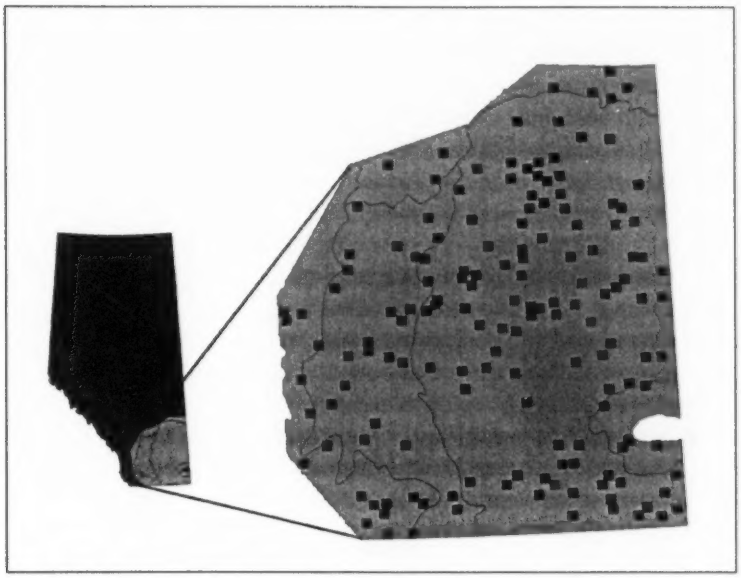

Figure 1: The ferruginous hawk project area and survey quadrats.

2.2 Survey Quadrats

The ferruginous hawk survey quadrats each measure 6.4 km by 6.4 km as designed by Schmutz (1982). Each quadrat was divided into one of two stratums, high or low, based on the percentage of native prairie habitat available in each quarter section. This habitat information was obtained from the Native Prairie Vegetation Inventory (Prairie Conservation Forum 2000). It was recommended in the summary of the 2005 inventory to review the stratification of the quadrats using the new Grassland Vegetation Inventory (GVI) for the 2010 inventory; however, this product was not available for the entire study area in time for the 2010 inventory. As a result, the Native Prairie Vegetation Inventory (NPVI) quadrats were used to obtain the required habitat information in the 2010 inventory. The high strata quadrats included all areas greater than or equal to 50% native prairie; whereas, the low strata quadrats included areas less than 50% native prairie. These quadrats were randomly allocated within the project area.

2.3 Observers

Quadrats were completed by trained observers of the Alberta Fish and Wildlife Division (AFWD), Alberta Conservation Association (ACA), Prairie Conservation Forum (PCF), Blood Tribe, University of Alberta, and the Canadian Wildlife Service. Each observer was instructed on survey methodology and species identification.

2.4 Survey Protocol

Surveys began on May 1, 2010 and continued to July 9, 2010. At the beginning of each survey, the start times, date of survey, number of observers, quadrat number, and weather conditions were recorded. However, surveys were not completed when winds exceeded 6 on the Beaufort

scale (Appendix A) and during periods of snow or rain. The observers used 4X4 trucks to travel on the roads present in each quadrat, but often used bikes, quads, or walked to areas not accessible with the trucks. Binoculars and spotting scopes were used to identify nests away from trails/roads, and to reduce human disturbance based on a recommendation by Schmutz (1999) and the Alberta Fish and Wildlife Division (2010).

Ferruginous hawks and other species of interest (Appendix B) were recorded on the ferruginous hawk data sheet (Appendix C) and plotted on the corresponding quadrat map. A Garmin GPS unit, programmed in NAD 83, was used to record the Universal Transverse Mercator (UTM) locations of the detected raptors. The quadrat maps were updated since the last survey period and plotted with previous ferruginous hawk nest points to facilitate observer searching.

When a ferruginous hawk nest was found, nest habitat data sheets were used to record the height of the nest, type of nesting structure, and percentage of various habitat types found within an 800 m by 800 m area of the nest. A nest was considered active if young were detected in the nest, new material was added to the nest, or if an adult was present on the nest. At the end of the survey, the end times were recorded; and the species summaries were filled out. All data was entered into the Fish and Wildlife Management Information System (FWMIS).

2.5 Data Analysis

Assuming that each nest represents two ferruginous hawk adults or one breeding pair, the number of active nests counted in each stratum, high and low, was used to calculate the breeding population (Taylor 2003). In a similar manner to Downey (2005), the Krebs (1989) method for stratified populations was utilized to estimate the breeding population with 95% confidence intervals (Appendix D).

3.0 RESULTS

3.1 Population Estimate

A total of 142 quadrats were surveyed in 2010; 74 in the high stratum and 68 in the low stratum. Six quadrats were not completed due to extreme wet weather during May and June; these quadrats were not replaced and all occurred in the high stratum. During the survey, an additional nine high strata quadrats were completed in the wrong areas due to inaccurate mapping of the quadrats. Analysis of location of the quadrats shows that they were eventually completed in the low stratum.

Within the completed quadrats, 41 ferruginous hawk nests were observed in the high stratum and 11 in the low stratum. Based on the total areas surveyed in each stratum and the number of nests, the ferruginous hawk population is estimated to be 643 ± 169 breeding pairs. This is similar to the 2005 estimate and still significantly lower than the 1992 population estimate (Table 1, Figure 2)

Table 1: The estimated number of ferruginous hawk pairs in Alberta, 1982-2010

Year	Number of Quadrats	Study Area (km^2)	Estimated Number of Pairs	95% Confidence Limit	95% Confidence Intervals
1982[a]	80	74,686	1082	40.5	653-1511
1987[a]	83	77,947	1791	28.5	1307-2275
1992[a]	85	77,947	1702	30.6	1181-2223
2000[b]	86	77,947	731	50.1	364-1097
2005[c]	148	77,157	618	26.2	456-780
2010	142	77,947	643	26.2	474-812

[a] Data from Schmutz (1993)
[b] Data from Stepnisky et al. (2002)
[c] Data from Downey (2005)

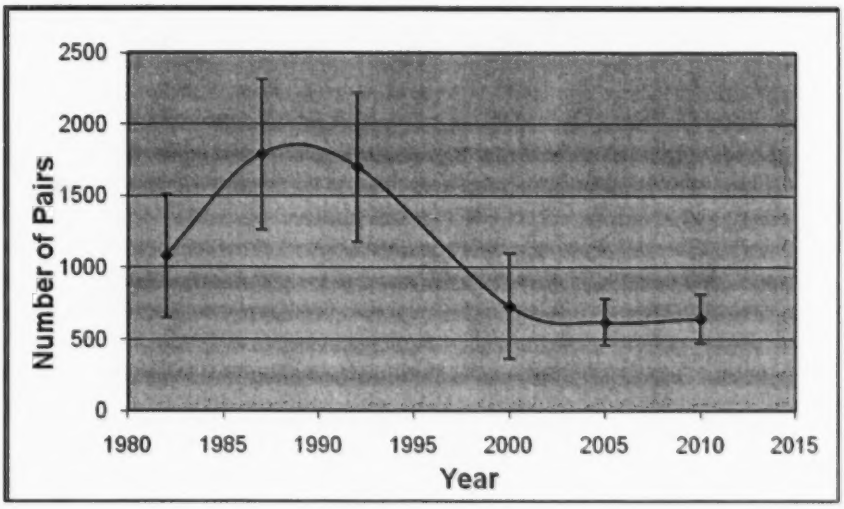

Figure 2: The estimated number of ferruginous hawk pairs and confidence intervals in Alberta from 1982-2010.

3.2 Population Trends

Overall, the ferruginous hawk population in Alberta exhibits a declining population trend when using linear regression analysis (Figure 3). When comparing the data collected from recent provincial inventories, the population appears to remain stabilized at low numbers since 2000 based on no significant difference detected in the number of nests per quadrat between 2000, 2005, and 2010 (Friedman Test Chi-square = 0.242, $p = 0.886$). Furthermore, no significant difference was found in the number of nests per quadrat between 2005 and 2010 ($z = -0.761$, $p = 0.447$) when using a Wilcoxon signed ranks test.

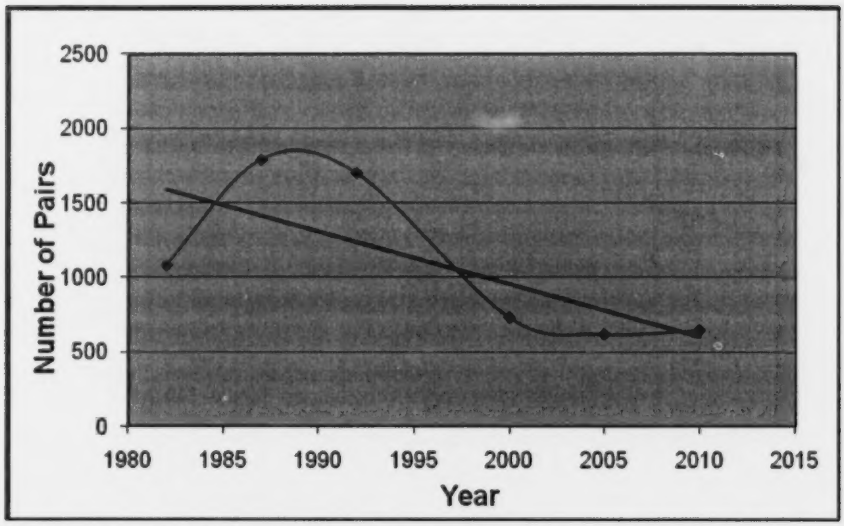

Figure 3: The declining population trend of ferruginous hawks in Alberta since 1982.

A sub sample of 30 quadrats, which were selected from six Alberta Fish and Wildlife resource management areas to adequately represent a portion of the project area (Taylor 2003), have been surveyed on an annual basis since 2003 to detect any significant events within the ferruginous hawk population between the 5 year inventories. Due to the weather, number of available observers, and the time available to complete these surveys, not all 30 quadrats were surveyed each year (Table 2). Consistent with Downey (2005), a linear regression detected no significant difference in the number of nests per quadrat between 2006 and 2010 ($t = -2.167$, $p = 0.119$); and overall, no significant difference in the number of nests per quadrat was found between 2000 and 2010 ($t = -0.753$, $p = 0.476$), which suggests that the ferruginous hawk population in Alberta has stabilized since 2000.

Table 2: Density of ferruginous hawk nests on quadrats monitored annually since 2003 and once every five years in 2000, 2005, and 2010.

Year	Number of Nests	Number of Quadrats Monitored	Density (Nests/Quadrat)
2000*	29	28	1.04
2003	25	30	0.83
2004	24	30	0.80
2005	25	29	0.86
2006	28	27	1.04
2007	26	23	1.13
2008	23	30	0.77
2009	24	28	0.86
2010	23	30	0.77

*Data from Stepnisky et al. (2002)

3.3 Additional Species

During this ferruginous hawk inventory, there were several incidental species detected on or in the vicinity of the quadrats (Appendix E). These included 93 red-tailed hawks (*Buteo jamaicenis*), 334 Swainson's hawks (*Buteo swainsoni*), 22 long-billed curlews (*Numenius americanus*), 23 loggerhead shrikes (*Lanius ludovicianus*), 27 Sprague's pipits (*Anthus spragueii*), five burrowing owls (*Athene cunicularia*), and five common nighthawks (*Chordelies minor*). These observations were entered into FWMIS.

4.0 DISCUSSION

The 2010 population estimate of 643 ± 169 breeding pairs is the second lowest estimate to date with the 2005 population estimate being the lowest. The methods used to derive the population estimate resulted in a greater level of precision compared to surveys completed between 1982 and 2000. The 2010 inventory likely reflects an accurate picture of the ferruginous hawk population; however, greater precision may have occurred if the methods used in 2005 had been strictly adhered to.

Based on a recommendation made by Saunders (2005), it was important to have 60% of the total quadrats allocated in the high stratum to increase the accuracy of the ferruginous hawk population estimate. During the 2010 inventory, approximately 52% and 48% of the quadrats surveyed occurred in the high and low stratums, respectively. Poor weather prevented some observers from accessing and surveying those quadrats allocated in the high stratum. The high strata quadrats occurred in areas of limited human infrastructure which decreases the accessibility of the sites for the observers. Limited access points and poor weather resulted in six quadrats not being completed in 2010. Additionally, nine quadrats were completed in the wrong areas due to a mapping issue which resulted in the quadrats being moved from the high to low stratum. This decreased the total number of high strata quadrats from 89 to 74 and may have resulted in decrease precision in the final population estimate. Future inventories should develop additional high strata quadrats that can be used to replace primary quadrats when administrative, access, or weather issues arise. Despite this issue, the current population estimate remains significantly lower than the 1992 population estimate.

In comparison to the 2000 and 2005 population estimates, the current estimate suggests that the ferruginous hawk population in Alberta has remained stable at low numbers since 2000; based on no significant difference detected in the number of nests per quadrat between 2000, 2005, and 2010. The recent stabilization from 2005 to 2010 may be attributed to the insignificant change between the number of high strata quadrats surveyed during those two inventories, as it relates roughly to the amount of cultivation occurring in each quadrat. Unfortunately, the degree of cultivation occurring in the immediate vicinity (800 m by 800 m) of an active nest was not measured during the 2010 inventory. Downey (2005) identified that prey abundance and not the amount of cultivation may be the primary factor that dictates population size. However, Richardson's ground squirrel surveys were not completed during the 2010 inventory. Therefore, the cause for this recent stabilization cannot be tied to either attribute.

The nest numbers collected from the 30 quadrats, which have been surveyed annually since 2003, further suggests that the ferruginous hawk population in Alberta has stabilized during the 2000-2010 monitoring period. It is emphasized that determining population trends in short periods is difficult. Due to changes in survey block locations, direct comparison between individual years is difficult; however, due to consistent sampling methodology, the survey does provide a core of long-term information. For future monitoring, it is recommended that survey block locations remain as consistent as possible.

During the 2010 inventory, 52 ferruginous hawk nests were counted in comparison to the 58 nests recorded in 2005. Although this reduction in the number of nests is insignificant, it may be attributed to the major weather events that occurred during April and May, 2010, assuming that no other significant changes in habitat and prey populations occurred on the surveyed quadrats since 2005. Based on data collected from the Lethbridge, Medicine Hat, Brooks, and Drumheller weather stations, the average precipitation, including snow and rainfall, that occurred in the Grasslands Natural Region during April and May, 2010, was 164.7 millimetres; whereas, April and May in 2005 experienced 30.1 millimetres (Environment Canada 2010). This large amount of precipitation combined with the wind from several spring storms may have caused a loss of nesting structures or nests through blow down, or nest abandonment due to inclement conditions leading to the loss of eggs or young. In addition, Downey (pers. comm.) reported that several previously-known nests had collapsed on the quadrats located in the southern portion of the project area possibly due to these abnormal weather events.

From previous research, it has been identified that numerous environmental factors, such as loss of native prairie habitat, decreases in food supply, climate change, interspecific competition, and increased human disturbance and development, may be linked to the overall decline in Alberta's ferruginous hawk population. Since the exact cause for this population decline remains unknown, it is important to continue intensive monitoring and research in both breeding and overwintering habitats.

Nest data, which incorporates the degree of human disturbances, type and height of nesting structures, and vegetation cover within an 800 m by 800 m area of any active nest, has been collected throughout the Grasslands Natural Region of Alberta to evaluate why a breeding pair of ferruginous hawks nest in a particular area. However, similar to Downey (2005), there is currently not enough data to conduct trend analysis. For future annual surveys and the 2015 provincial inventory, nest data should be collected for ferruginous hawks present on any of the quadrats.

As part of the current provincial ferruginous hawk recovery plan, the impacts of human and industrial disturbance are being evaluated. A PhD student from the University of Alberta is currently assessing the effects of oil and gas development on mortality risk, habitat use, and reproduction of ferruginous hawks by tracking individuals in Alberta and Saskatchewan (Downey pers. comm.). This information collected will provide great insight into the movements of these raptors, and thus, could help AFWD in the revision of current setback distances for oil and gas development.

As an ongoing tri-national migration study, FerruginousHawk.org (2007) continues to track telemetered hawks to assess the philopatric behaviour, which is exhibited by most ferruginous hawks, and determine the factors that influence survival and mortality rates. International projects, such as above, should continue to help build upon the current knowledge of this raptor's movements and ecology.

In conclusion, the exact cause of the overall decline in Alberta's ferruginous hawk population still remains unknown. In addition, the factors that influenced the recent stabilization of Alberta's ferruginous hawk population may be due to the insignificant changes in cultivation levels or local increase in prey abundance, but this needs to be further investigated. Since Alberta's landscape continues to change, it is important to manage the ferruginous hawk and its habitat accordingly by consulting with landholders, industrial developers, municipalities, and the public as outlined in the Alberta Ferruginous Hawk Recovery Plan 2009-2014 (Alberta Ferruginous Hawk Recovery Team 2009).

5.0 RECOMMENDATIONS

In order to manage and monitor the ferruginous hawk, the following initiatives should be carried out:

1. A full survey should be completed every 5 years.

Continued monitoring is necessary to understand the population trends and the effects of management initiatives. The next provincial inventory should be conducted in 2015.

2. The survey quadrats should be restratified based on the amount of native prairie habitat when the Grassland Vegetation Index is completed.

The Native Prairie Vegetation Inventory (NPVI) was used to stratify the survey quadrats. However, the NPVI is a coarse model that defines habitat at the quarter section level, and has resulted in some discrepancies between predicted habitat values and observed values. The Grassland Vegetation Index (GVI) that is currently being developed will examine habitat at a finer scale than the NPVI. GVI has been completed for all areas South of Calgary to the US border, and Calgary East to the Saskatchewan border (Fent pers. comm.). When the GVI is completed, it should be used to reassess the stratification of all 150 quadrats to reconfirm which strata each quadrat is allocated to.

3. Increase the number of quadrats to be surveyed in 2015.

More high strata quadrats need to be added to the 2015 inventory to meet the 60% requirement (Saunders 2005). Secondly, it is important to have extra quadrats, which are allocated in the high stratum, on hand to replace those historical quadrats that may not get surveyed in 2015 as a result of significant weather events or other uncontrollable events. If more quadrats are surveyed, a more precise ferruginous hawk population estimate could be obtained in 2015.

4. A sub sample of quadrats should be surveyed annually.

Annual monitoring of a sub sample of quadrats allows insight into the population dynamics between the 5-year studies (Taylor 2003). This can also be used to identify environmental factors, which may have altered population trends such as weather phenomena, change in prey densities, and nest site availability.

5. Richardson's ground squirrel populations should continue to be monitored in conjunction with the ferruginous hawk surveys.

The 2003 survey method for ground squirrels should be continued in conjunction with the ferruginous hawk annual monitoring surveys and the 2015 population survey. This will allow further insight into this important relationship and allow better management decisions for the ferruginous hawk.

6. Future research should concentrate on habitat features and land uses with suspected negative or positive influence on the ferruginous hawks.

The effects of many habitat features are unknown. Future research should concentrate on the effects of oil and gas development, nest site availability, and nest site habitat, which may influence the ferruginous hawks. This information is critical to understanding the habitat requirements and the effects of human disturbance on the species.

7. Accomplish the recovery objectives outlined in the Alberta Ferruginous Hawk Recovery Plan 2009-2014.

These objectives include, but are not limited to: sustaining 1,200 pairs of ferruginous hawks in Alberta by 2015, maintaining the current range of native grasslands in Alberta, and restoring native prairie where the opportunity is present (Alberta Ferruginous Hawk Recovery Team 2009).

8. Recruitment rates of ferruginous hawks in Alberta should be further investigated.

The number of nestlings reaching fledging and ultimately becoming breeding adults remains unknown for Alberta's ferruginous hawk population. In collaboration with the province of Saskatchewan and the state of Montana, bird banding and GPS-tracking should be conducted on an annual basis to determine the success of nestlings reaching the fledging stage.

9. Within the Grassland Natural Region the ferruginous hawk should be identified as a primary management species.

Within the Grassland Natural Region of Alberta, the ferruginous hawk should be identified as a primary management species by government and conservation agencies. It is important that the habitat requirements of this species be incorporated into habitat conservation strategies of conservation organizations such as Operation Grassland Community, Alberta Conservation Association, Nature Conservancy of Canada, Duck Unlimited Canada, and others.

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7.0 PERSONAL COMMUNICATIONS

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Livio Fent, Section Head, Data Management, Sustainable Resource Development, Resource Information Management Branch.

Appendix A

Beaufort Wind Scale						
Force	Wind Speed			WMO Description	Wind Speed Indicators	
	MPH	Knots	KPH		At Sea	On Land
0	<1	<1	<1	Calm	Smooth as glass	Calm; smoke rises vertically
1	1-3	1-3	1-5	Light Air	Ripples with appearance of scales; no foam crests	Smoke drift indicates wind direction; vanes do not move
2	4-7	4-6	6-11	Light Breeze	Small wavelets; crests of glassy appearance	Wind felt on face; leaves rustle; vanes begin to move
3	8-12	7-10	12-19	Gentle Breeze	Large wavelets; crests begin to break, scattered whitecaps	Leaves & small twigs in motion; light flags extended
4	13-18	11-16	20-29	Moderate Breeze	1-4 ft. waves; numerous whitecaps	Leaves, & loose paper raised up; flags flap; small branches move.
5	19-24	17-21	30-38	Fresh Breeze	4-8 ft waves; many whitecaps; some spray	Small trees begin to sway; flags flap & ripple
6	25-31	22-27	39-50	Strong Breeze	8-13 ft waves forming white caps everywhere; more spray	Large branches in motion; whistling heard in wires
7	32-38	28-33	51-61	Near Gale	13-20 ft. waves; white foam blows in streaks	Whole trees in motion; resistance felt in walking against wind
8	39-46	34-40	62-74	Gale	13-20 ft. waves; edges of crests begin to break; foam in streaks	Whole trees in motion; resistance felt in walking against wind
9	47-54	41-47	75-86	Strong Gale	20 ft. waves; sea begins to roll; dense streaks of foam	Slight structural damage occurs; shingles blow from roofs
10	55-63	48-55	87-101	Storm	20-30 ft. waves; white churning sea; rolling is heavy; reduced visibility	Trees broken or uprooted; considerable structural damage occurs
11	64-74	56-63	102-120	Violent Storm	30-45 ft. waves; white foam patches	Widespread damage to trees & buildings
12	75+	64+	120+	Hurricane	45 ft.+ waves; white sea; driving spray	Severe & extensive damage

Retrieved from http://www.jbrau.com/fun/bnb-bfrt.htm

Appendix B

Additional Species to Record

Common / Latin names	Data Sheet Code
American Badger / *Taxidea taxus*	BADG
Baird's Sparrow / *Ammodramus bairdii*	BDSP
Bobcat / *Lynx rufus*	BOBC
Bobolink / *Dolichonyx oryzivorus*	BOBO
Bullsnake / *Pituophis catenifer*	BULL
Burrowing Owl / *Athene cunicularia*	BUOW
Golden Eagle / *Aquila chrysaetos*	GOEA
Great Blue Heron / *Ardea herodias*	GBLH
Loggerhead Shrike / *Lanius ludovicianus*	LOSH
Long-Billed Curlew / *Numenius americanus*	LBCU
Long Tailed Weasel / *Mustela frenata*	LTWE
Mountain Plover / *Charadrius montanus*	MTPL
Peregrine Falcon / *Falco peregrinus*	PEFA
Piping Plover / *Charadrius melodus*	PIPL
Prairie Falcon / *Falco mexicanus*	PRFA
Prairie Rattlesnake / *Crotalus viridis*	PRRA
Pronghorn / *Antilocapra americana*	PRON
Red-tailed Hawk / *Buteo jamaicensis*	RTHA
Sage Grouse / *Centrocercus urophasianus*	SAGR
Sage Thrasher / *Oreoscoptes montanus*	SATH
Sandhill Crane / *Grus canadensis*	SACR
Sharp-tailed Grouse / *Tympanuchus phasianellus*	STGR
Short-eared Owl / *Asio flammeus*	SEOW
Sprague's Pipit / *Anthus spragueii*	SPPI
Swainson's Hawk / *Buteo swainsoni*	SWHA
Swift Fox / *Vulpes velox*	SWFO
Thirteen-lined Ground Squirrel / *Spermophilus tridecemlineatus*	TLGS
Trumpeter Swan / *Cygnus buccinator*	TPSW
Upland Sandpiper / *Bartramia longicauda*	UPSA

Appendix C

Ferruginous Hawk Data and Map Sheet

Date (DDMMYY): Quadrat #: Start Time: End Time:
Observers: Total Hours:
General Weather Conditions:

Habitat Summary % Cultivation: % NP: % Tame:
% Not Surveyed:
Are potential nesting structures present? Description:
Site Photo Taken?
Site Photo Coordinates and Direction:

Species Summary Species Nests Adults Young

Species Observations						UTM	Nad 83
ID	Species	Nests	Adults	Young	Activity	Easting	Northing
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

Observer Comments:

Appendix D

Stratified Random Sampling (Krebs 1989)

The following formulas were used to calculate the population estimate of ferruginous hawk in Alberta. For full explanation please refer to Krebs (1989) method for a stratified population estimate.

A) Population total: sum of the population estimate for each stratum.

$$X_{st} = Nx_{st}$$

X_{st} = Population Total
N = Number of sample units in the entire population
x_{st} = Stratified mean/sampling unit

B) The overall mean/sampling unit for the population: the mean number of individuals observed per stratum.

$$xst = \frac{\sum_{h=1}^{L} Nhxh}{N}$$

x_{st} = Stratified population mean/sampling unit
N_h = Size of stratum h
h = Stratum number
x_h = Observed mean for stratum h
N = Total population size = $\sum N_h$

C) Stratum Weight: percent of total area in each stratum.

$$Wh = \frac{Nh}{N}$$

N_h = Size of stratum h
N = Size of entire statistical population

D) Variance of a stratified mean: variance of the mean number of individuals/ stratum

$$\text{Variance of } (xst) = \sum_{h=1}^{L} \left[\frac{w_h^2 s_h^2}{nh} (1 - fh) \right]$$

w_h = Stratum weight
s_h^2 = Observed variance of stratum
n_h = Sample size of stratum h
f_h = Sampling fraction in stratum h= n_h/N_h

E) Variance of the Population Mean: variance of the entire population.

Variance of the Population Mean (X_{st}) = $(N)^2$(variance of x_{st})

F) Standard Error: required to determine the confidence limits

$$\text{Standard Error of}(x_{st}) = \sqrt{\text{variance of } x_{st}}$$

G) Effective Degrees of Freedom: required to determine the value of t (95% CI).

$$d.f. = \frac{(\sum_{h=1}^{L} g_h s_h^2)^2}{\sum_{h=1}^{L} [g_h^2 s_h^4 / (n_h - 1)]}$$

$g_h = N_h(N_h - n_h)/n_h$
s_h^2 = Observed variance in stratum h
n_h = Sample size in stratum h
N_h = Size of stratum h

H) Confidence limits for entire population

$$\text{Xst} \pm t\alpha(\text{standard error of Xst})$$

Appendix E

Incidental Species Detected during the 2010 Ferruginous Hawk Inventory

Species	Nests	Adult	Young
ALDER FLYCATCHER	0	1	0
AMERICAN BITTERN	0	1	0
AMERICAN CROW	3	4	3
AMERICAN KESTREL	1	7	2
AMERICAN WHITE PELICAN	1	2	3
BLACK-CROWNED NIGHT-HERON	0	1	0
BAIRD'S SPARROW	0	7	0
BROWN THRASHER	0	1	0
BURROWING OWL	3	5	0
CANADA GOOSE	1	52	0
COMMON NIGHTHAWK	0	5	0
COMMON RAVEN	1	1	1
EASTERN KINGBIRD	0	1	0
GREAT HORNED OWL	6	19	13
GOLDEN EAGLE	0	1	0
GRAY PARTRIDGE	0	4	0
HORNED LARK	0	1	0
KILLDEER	0	1	0
LONG-BILLED CURLEW	0	22	0
LESSER SCAUP	0	1	0
LOGGERHEAD SHRIKE	0	23	0
MALLARD	0	14	0
MCCOWN'S LONGSPUR	0	7	0
MERLIN	0	4	0
NORTHERN HARRIER	0	62	0
NORTHERN PINTAIL	0	8	0
PRONGHORN	0	42	6
RED-HEADED WOODPECKER	0	1	0
RED-TAILED HAWK	26	93	0
SHORT-EARED OWL	0	1	0
SORA	0	2	0
SPRAGUE'S PIPIT	0	27	0
SHARP-TAILED GROUSE	0	8	4
SWAINSON'S HAWK	109	334	5
TURKEY VULTURE	0	3	0
VESPER SPARROW	0	3	0
WESTERN MEADOWLARK	0	1	0
WHIMBREL	0	44	0
WILSON'S PHALAROPE	0	1	0
WHITE-TAIL DEER	0	3	0

For a list of additional reports in the Alberta Fish and Wildlife Division - Species at Risk Series please go to our website:

http://srd.alberta.ca/BioDiversityStewardship/SpeciesAtRisk/ProgramReports.aspx